Is permafrost a first order control on rock-slope deformation in Norway?

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The impact of long-term permafrost variabilities on large unstable rock slopes is challenging to quantify. Yet, gaining a deeper understanding of permafrost as potential first order control on rock-slope deformation is critical to evaluate current and future deformation and failure scenarios and the associated risk for human life and infrastructure. More than 583 rock slopes in Norway are classified as unstable, and several are located at latitudes and altitudes that are prone to permafrost variations. We begin to address the difficult task of estimating the initiation of post-glacial rock-slope deformation and potential paleo-slip rates for selected large rockslides with cosmogenic nuclide dating and compare those with a reconstructed permafrost evolution since deglaciation. At two low elevation slope instabilities in western Norway, where permafrost remained absent during the Holocene, deformation started during or shortly after deglaciation. Initial deformation of three other sites, which today lie within or at the border of permafrost zones, coincides with periods during or at the end of the Holocene Thermal Maximum (between 4. 5 and 8 ka) when permafrost was mostly degraded. This suggests that the presence of permafrost in Norwegian rock slopes had a stabilising effect over several millennia after deglaciation. Surface exposure ages along outcropping sliding planes indicate a general decrease in Holocene slip rates at all studied sites. However, recent measurements at three sites situated at or close to the lower limit of elevational permafrost show a moderate to strong acceleration, compared to the reconstructed Holocene deformation rates. These findings imply that gravitational instabilities are sensitive to permafrost degradation in the Arctic and Subarctic.

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